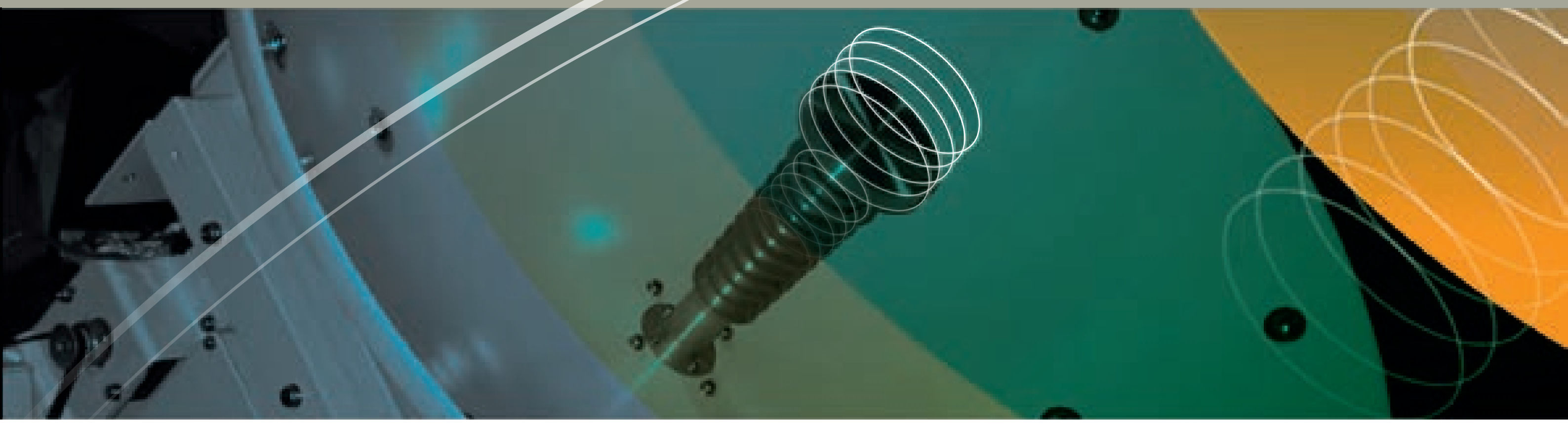
CHAMP



The ultra-fast tool for combined design

of rotationally symmetric horns and reflector terminals

CHAMP offers the fastest, most accurate and reliable design optimization tools for horn and reflector antenna terminals with rotational symmetry. CHAMP fulfills the demanding requirements from antenna engineers working in the aerospace, defense and telecommunications industries, as well as within science, research and radio astronomy. CHAMP has evolved over decades to become a trusted, efficient and well-validated tool, merging RF modeling, numerical optimization and a graphical user interface into a solid entity.

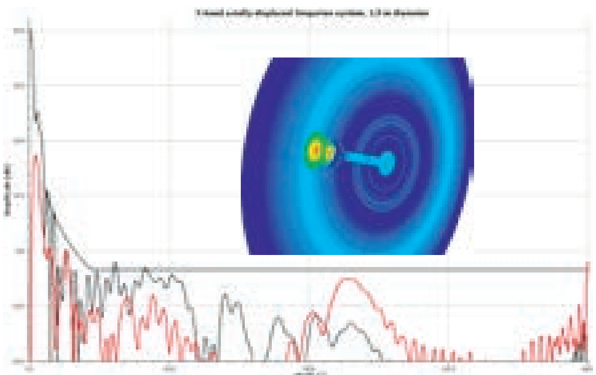
What can you do with CHAMP?

- Accurately analyze circular, conical, stepped and corrugated horns, lenses and reflectors
- Optimize the horns with respect to VSWR, co- and cross-polar peak gain, XPD, phase-center location and beam symmetry
- Simultaneously optimize the feeds and the shape of one or more reflectors, also with respect to user-defined co- and cross-polar sidelobe envelopes imposed by regulatory authorities and operators
- Include in the analysis any dielectric material, often used as support structure between the feed and the first reflector
- Statistical tolerance analysis
- Perform numerous post-analyses of the designs as a function of frequency, such as
  - horn aperture efficiency
  - best-fit phase center
  - beam width
  - fields inside horns
  - aperture fields of horns

How does CHAMP make it happen?

CHAMP's numerous features not only guarantee a smooth learning curve, but also facilitate the entire design procedure of horns and reflector terminals. The tools include:

- Initial set-up wizards:
  - Define radially-corrugated horns based on only frequency band and desired beam-width, and prepare all necessary parameters for a frequency analysis. Well-established rules-of-thumb are applied during the process, leading to a near-perfect horn performance, which can of course be further optimized subsequently
  - Define dual reflector antennas of the axially-displaced or ring-focus type by simply giving the main- and sub-reflector diameter, f/D and sub-reflector subtended angle



The initial setup of a 40λ axially-displaced ellipse reflector is completed within seconds and compared to a sidelobe envelope reference curve.

- Component library with pre-defined geometries
  - Waveguide and waveguide steps
  - Conical sections
  - Single- and dual-depth corrugated sections
  - Corrugated mode converter section
  - Axial corrugations

- Point and click definition of geometries
  - The exterior of the horn and any reflectors is easily created with a few mouse clicks. Subsequently, precise data can be entered for the selected points, or the points can be selected as optimization variables. Piece-wise linear as well as spline interpolation are available

- Variables and expressions
  - Any geometrical parameter in CHAMP can be expressed as a variable, or as an arithmetic or trigonometric expression involving variables

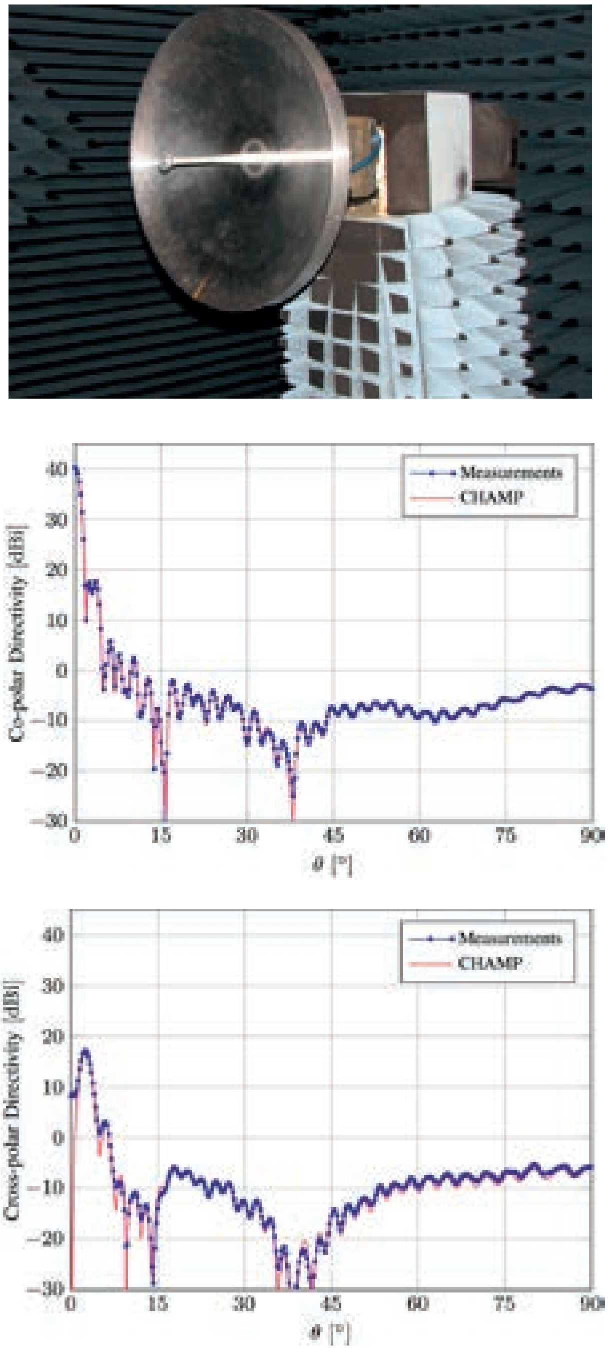
- Optimization
  - The user can easily formulate design goals in terms of familiar antenna parameters
  - Variables are included or excluded from the optimization through simple drag-and-drop
  - Upper and lower bounds may be specified on the variables

A look into the engine room
CHAMP employs two techniques for the EM modelling: mode matching and method of moments. The implementation of both of these techniques has been perfected by TICRA's engineers with the aim of providing a tool that is highly accurate and thereby guarantees a very close correlation between predictions and actual design performance, while at the same time being so fast that optimization of even very large structures is achievable in practice.

The two methods are complementary with the mode matching applied to the wave propagation inside the waveguide structure, while the method of moments handles the radiation and scattering in the exterior. They are rigorously combined to account for interaction between regions.

Mode matching – horn interior
In this formulation the horn is assumed to be excited at the waveguide input by either the fundamental TE_{11} mode or one of the tracking modes TE_{21}, TE_{01} or TM_{01}. The horn is segmented into elementary modules depending on the type of corrugations. Smooth-walled horns are discretized into elementary modules based on well-established rules.

A full-wave expansion of the field into cylindrical modes is performed in each elementary module. The number of modes in the expansion depends on the diameter of the actual elements, and is automatically determined. Evanescent modes are fully accounted for, and by cascading the generalized scattering matrices of all modules, the overall generalized matrix for the horn inner structure – throat to aperture – is obtained.



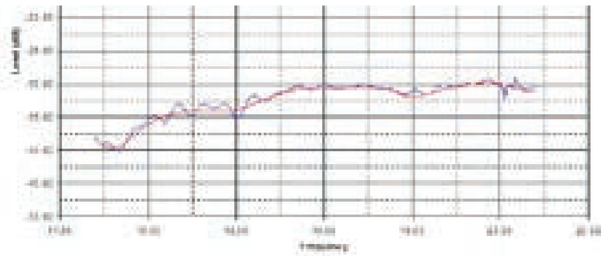
A 44λλreflector designed with a dielectrically supported hat-feed and a shaped reflector. All components are optimized by CHAMP, and the measurements carried out at the Technical University of Denmark. A full CHAMP analysis performed in a few seconds reveals the extremely good correlation between measurements (in blue) and predictions (in red).

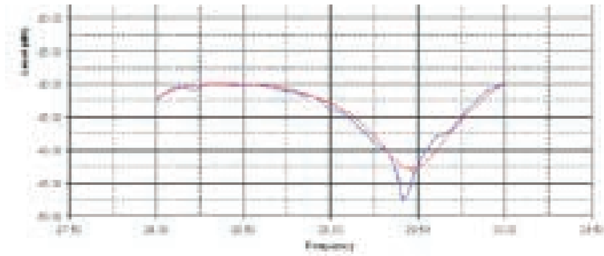
Method of Moments – horn exterior and reflectors
The radiation from the horn aperture and subsequent scattering in external structures and reflectors is determined by a Body-of-Revolution MoM. For a stand-alone horn any commercially available solver should provide an answer within a few minutes. However, it is an entirely different matter when reflectors, lenses and dielectrics are involved, and the runtime with standard solvers is often measured in hours. This leaves a full numerical system optimization an unachievable dream.

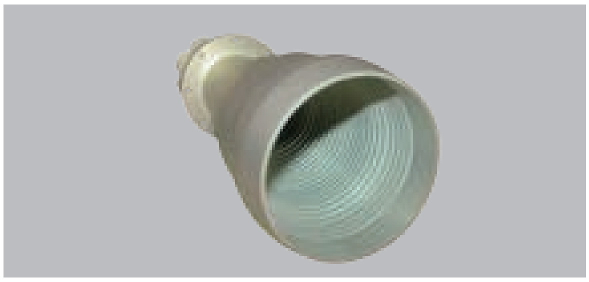
The dedicated MoM solver in CHAMP has been redesigned from the ground up to combine full-wave accuracy with superior modeling speed. The innovative formulation utilizes higher-order current- and surface-expansions to achieve the goal: Even reflectors with a diameter of 100 wavelengths can be handled in a couple of seconds on a laptop. This is a pre-requisite for multi-frequency, multi–parameter optimization.

Optimization
The optimization tool box contains four choices of algorithms: minmax, GA, least-squares and simplex. Experience shows that the availability of different techniques can be very helpful towards obtaining a global optimum in a reasonable time. The nature of the optimization problem is such that many local optima may exist, in which case the typical procedure would be to first apply the GA to move towards a global optimum, followed by a minmax to fine-tune the solution to the best performance.

Validation by measurements
CHAMP's modeling capability for corrugated horns has been validated over many years through widespread use among our customers. The results presented above for the new features thoroughly substantiate the claim that the program represents a fast and trust-worthy tool for the design and analysis of rotationally symmetric horns, lenses and reflector systems, applicable to the most challenging design tasks faced by engineers in the antenna industry.

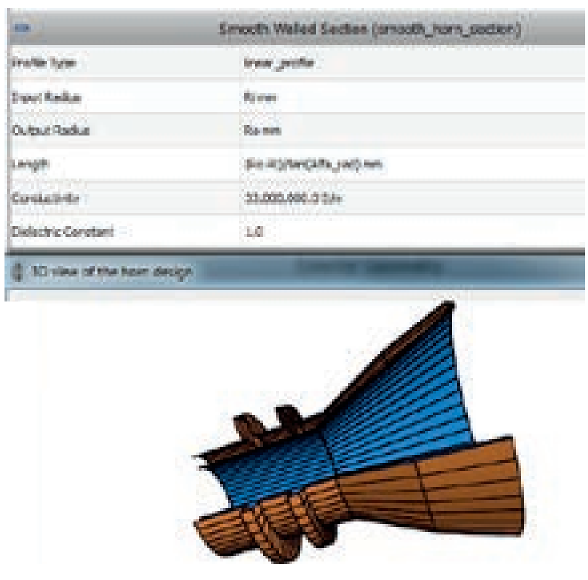






With the optimizer in CHAMP it was possible to enhance the aperture efficiency of an already well-designed corrugated Ka-band satellite feed over both Tx and Rx bands. The design was done by Thales Alenia Space, France, who also validated the design. The figures show the outstanding agreement between test and predictions of the VSWR.

The capability of handling dielectric material in the moment method implementation enables full design and analysis of horn-fed lenses. The picture shows a corrugated horn equipped with a grooved lens.



A simple conical horn section is defined by the input and output radii and the section length. In this example the horn is parameterized in terms of the flare angle, enabling optimization of, for example, the aperture radius whilst keeping the angle constant.

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